

WHAT IS CLAIMED IS:

1. A system for pumping thermal energy, comprising:
a membrane permeator for removing vapor from a process gas and for
providing a vapor-depleted process gas; and
a gas-liquid contactor for adding vapor from a liquid to a said vapor-
depleted gas to produce a vapor-added process gas,
wherein said system transfers a quantity of thermal energy from said liquid
to said vapor-added process gas.
2. The system of claim 1, wherein said vapor-depleted process gas is routed
from said membrane permeator to said gas-liquid contactor such that said process
gas circulates in a loop that includes said membrane permeator and said gas-liquid
contactor.
3. The system of claim 2, further comprising a pumping means for
facilitating circulation of said process gas in said loop.
4. The system of claim 1,
further comprising a reservoir for supplying said liquid to said gas-liquid
contactor,
wherein said liquid is routed from an output of said gas-liquid contactor to
said reservoir such that said liquid circulates in a loop that includes
said gas-liquid contactor and said reservoir.
5. The system of claim 4, further comprising a pump for facilitating
circulation of said liquid in said loop.
6. The system of claim 1,
wherein said vapor permeates from a feed side of said membrane permeator
to a permeate side of said membrane permeator, and

wherein said system further comprises an arrangement for increasing a driving force between said feed side and said permeate side.

7. The system of claim 6, wherein said arrangement employs a technique selected from the group consisting of (a) sweeping a dry gas proximate to said permeate side, (b) applying a vacuum to said permeate side, and (c) allowing a portion of said process gas to permeate said membrane.

8. The system of claim 6, wherein said arrangement refluxes a portion of said vapor-depleted process gas into said permeate side.

9. The system of claim 1, wherein said process gas enters said system at a first temperature, and subsequent to being routed through said membrane permeator, said process gas exists said system at a second, colder temperature.

10. The system of claim 1, wherein said liquid enters said system at a first temperature, and subsequent to being routed through said gas-liquid contactor, said liquid exits said system at a second, colder temperature.

11. The system of claim 1, wherein said vapor-added gas is routed to a space for chilling of said space.

12. The system of claim 1,
wherein said membrane permeator is a first membrane permeator, and
wherein said system further comprises a second membrane permeator for
reducing humidity of said vapor-added process gas.

13. The system of claim 1, further comprising a heat exchanger for transferring energy between said process gas and said liquid, before said liquid enters said gas-liquid contactor and after said process gas exits from said gas-liquid contactor.

14. The system of claim 1, further comprising a heat exchanger for transferring energy between said process gas and said liquid, before said process gas enters said gas-liquid contactor and after said liquid exits from said gas-liquid contactor.

15. The system of claim 1, further comprising a heat exchanger through which said process gas is routed for chilling of a media.

16. The system of claim 1, further comprising a heat exchanger through which said liquid is routed from said gas-liquid contactor for chilling of a media.

17. The system of claim 1, wherein said vapor-depleted process gas is routed to a space for chilling of said space.

18. The system of claim 1, wherein said gas-liquid contactor comprises a component selected from the group consisting of (a) cooling tower, (b) a spray contactor, (c) an atomizing contactor, (d) a dripping contactor, (e) a sprinkler contactor, (f) a wet pad contactor, (g) a packed column, (h) a plates column, (i) a baffle tower, (j) a membrane contactor, (k) a humidifier, (l) an evaporator and (m) a flash evaporator.

19. A system for pumping thermal energy, comprising:
an energy source for heating a vapor-containing gas; and
a membrane permeator for removing vapor from said vapor-containing gas
and for providing a resultant vapor,
wherein said system transfers a quantity of thermal energy from said energy source to said resultant vapor.

20. The system of claim 19, wherein said energy source comprises a component selected from the group consisting of a compressor and a blower.

21. The system of claim 19, wherein said energy source comprises a heater.

22. The system of claim 21, wherein said heater uses a source of energy selected from the group consisting of (a) waste heat, (b) solar heat, (c) low level heat, (d) a furnace, (e) flue gas, (f) geothermal heat, (g) steam, (h) hot water, (i) burning fuel, (j) burning gas, (k) electrical and (l) geothermal.

23. The system of claim 19, further comprising a heat exchanger through which said resultant vapor is routed for heating a media.

24. The system of claim 19,
wherein said vapor permeates from a feed side of said membrane permeator to a permeate side of said membrane permeator, and
wherein said system further comprises an arrangement for increasing a driving force between said feed side and said permeate side.

25. The system of claim 24, wherein said arrangement employs a technique selected from the group consisting of (a) sweeping a dry gas proximate to said permeate side, (b) applying a vacuum to said permeate side, and (c) allowing a portion of said vapor-containing gas to permeate said membrane.

26. The system of claim 19,
wherein said membrane permeator discharges a retentate gas, and
wherein said arrangement refluxes a portion of said retentate gas into said permeate side.

27. The system of claim 19,
wherein said heater comprises a heat exchanger for transferring heat from a waste heat source to said vapor-containing gas, and
wherein said quantity of thermal energy comprises thermal energy from a source selected from the group consisting of (a) a waste heat, (b) solar heat, (c) low level heat, (d) a furnace, (e) flue gas, (f) geothermal heat,

(g) steam, (h) hot water, (i) burning fuel, (j) burning gas, (k) electrical and (l) geothermal.

28. The system of claim 19, further comprising a gas-liquid contactor that adds vapor from a liquid to a process gas to produce said vapor-containing gas.

29. The system of claim 28, wherein said gas-liquid contactor comprises a component selected from the group consisting of (a) cooling tower, (b) a spray contactor, (c) an atomizing contactor, (d) a dripping contactor, (e) a sprinkler contactor, (f) a wet pad contactor, (g) a packed column, (h) a plates column, (i) a baffle tower, (j) a membrane contactor, (k) a humidifier, (l) an evaporator and (m) a flash evaporator.

30. The system of claim 28, wherein said system transfers a quantity of thermal energy from said liquid to said resultant vapor.

31. The system of claim 30, wherein said resultant vapor releases said quantity of thermal energy at a temperature higher than a temperature of said liquid.

32. The system of claim 30, wherein said resultant vapor heats media by condensation in a heat exchanger and releases latent heat.

33. The system of claim 28, further comprising a heat exchanger for transferring energy between said process gas and said liquid, before said liquid enters said gas-liquid contactor and after said process gas exits from said gas-liquid contactor.

34. The system of claim 28, further comprising a heat exchanger for transferring energy between said process gas and said liquid, before said process gas enters said gas-liquid contactor and after said liquid exits from said gas-liquid contactor.

35. The system of claim 28,
wherein said heater is a first heater and said quantity of thermal energy is a
first quantity of thermal energy,
wherein said system further comprises a second heater for heating said
liquid,
and wherein said system further transfers a second quantity of thermal
energy from said heater to said resultant vapor.

36. The system of claim 35,
wherein said second heater comprises a heat exchanger for transferring heat
from a waste heat source to said liquid, and
wherein said second quantity of thermal energy comprises thermal energy
from said waste heat source.

37. A system for pumping thermal energy, comprising:
a heater for heating a liquid;
a gas-liquid contactor for adding vapor from said liquid to a process gas to
produce a vapor-containing gas;
a membrane permeator for removing said vapor from said vapor-containing
gas and for providing a resultant vapor;
wherein said system transfers a quantity of thermal energy from said heater
to said resultant vapor.

38. The system of claim 37, further comprising a heat exchanger through
which said resultant vapor is routed for heating a media.

39. The system of claim 38, wherein said resultant vapor heats said media by
condensation and releases latent heat.

40. The system of claim 37,

wherein said vapor permeates from a feed side of said membrane permeator to a permeate side of said membrane permeator, and
wherein said system further comprises an arrangement for increasing a driving force between said feed side and said permeate side.

41. The system of claim 40, wherein said arrangement employs a technique selected from the group consisting of (a) sweeping a dry gas proximate to said permeate side, (b) applying a vacuum to said permeate side, and (c) allowing a portion of said vapor-containing gas to permeate said membrane.

42. The system of claim 37,
wherein said membrane permeator discharges a retentate gas, and
wherein said arrangement refluxes a portion of said retentate gas into said permeate side.

43. The system of claim 37,
wherein said heater comprises a heat exchanger for transferring heat from a waste heat source to said liquid, and
wherein said quantity of thermal energy comprises thermal energy from a source selected from the group consisting of (a) a waste heat, (b) solar heat, (c) low level heat, (d) a furnace, (e) flue gas, (f) geothermal heat, (g) steam, (h) hot water, (i) burning fuel, (j) burning gas, (k) electrical and (l) geothermal.

44. The system of claim 37, further comprising a heat exchanger for transferring energy between said vapor-containing gas and said liquid, before said liquid enters said gas-liquid contactor and after said vapor-containing gas exits from said gas-liquid contactor.

45. The system of claim 37, further comprising a heat exchanger for transferring energy between said process gas and said liquid, before said process

gas enters said gas-liquid contactor and after said liquid exits from said gas-liquid contactor.

46. The system of claim 37, wherein said gas-liquid contactor comprises a unit selected from the group consisting of (a) cooling tower, (b) a spray contactor, (c) an atomizing contactor, (d) a dripping contactor, (e) a sprinkler contactor, (f) a wet pad contactor, (g) a packed column, (h) a plates column, (i) a baffle tower, (j) a membrane contactor, (k) a humidifier, (l) an evaporator and (m) a flash evaporator.

47. A method for pumping a quantity of thermal energy, comprising:
adding vapor from a liquid to a process gas, thus yielding a vapor-containing gas; and
employing a membrane permeator to remove said vapor from said vapor-containing gas, thus providing a resultant vapor,
wherein said quantity of thermal energy is transferred from said liquid to said resultant vapor.

48. A method for pumping a quantity of thermal energy, comprising:
employing a heater to heat a vapor-containing gas; and
employing a membrane permeator to remove vapor from said vapor-containing gas, thus providing a resultant vapor,
wherein said quantity of thermal energy is transferred from said heater to said resultant vapor.

49. A method for pumping a quantity of thermal energy, comprising:
employing a heater to heat a liquid;
adding vapor from said liquid to a process gas to produce a vapor-containing gas; and
employing a membrane permeator to remove said vapor from said vapor-containing gas, thus providing a resultant vapor,

wherein said quantity of thermal energy is transferred from said heater to said resultant vapor.

50. A method for pumping thermal energy, comprising:
removing vapor from a process gas with a membrane permeator to yield a vapor-depleted gas; and
adding vapor from a liquid to a said vapor-depleted gas via a gas-liquid contactor to yield a vapor-added gas,
wherein said method transfers a quantity of thermal energy from said liquid to said vapor-added gas.